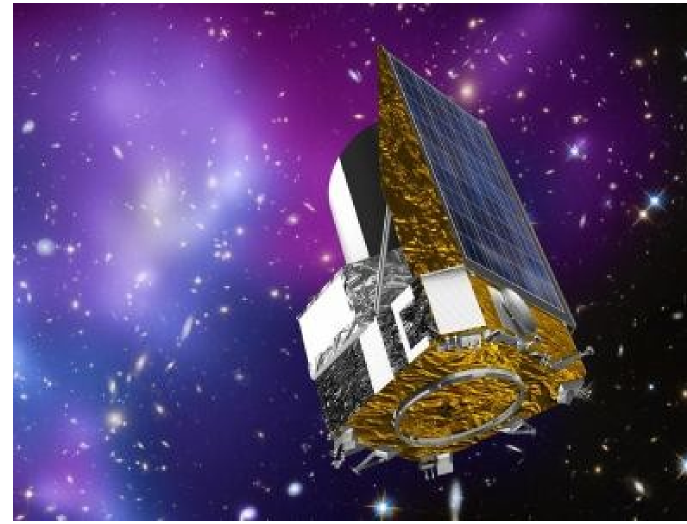
Les défis informatiques des grands relevés



Colloque national Dark Energy
23 – 25 octobre 2018

Dominique Boutigny

Acknowledgments

- Yannick Giraud-Héraud, Ken Ganga, Cécile Calvet, Cyrille Rosset (APC) for Euclid

- Fabio Hernandez (CC-IN2P3) for LSST Data Release Processing

The size of the problem

LSST :

- $2.75\ 10^6$ visits (x2 snaps x189 CCD x16 Mpixels)
- 20 TB / 24h including calibrations
- 60 PB raw data / year
- Final dataset : 500 PB total
- Peak computing power: 1.8 PFlops
- $37\ 10^9$ sources
- $3\ 10^9$ galaxies for WL
- Final catalog DR11 : 15 PB

50% of the processing in France

Euclid :

- 140 GB / 24h
- Final dataset: 175 PB
- Peak Computing power: 0.6 PFlops
- $12\ 10^9$ sources
- $1.5\ 10^9$ galaxies for WL
- $1.5\ 10^5$ spectroscopic redshifs

30% of the processing in France

LSST Data Products

- A stream of ~10 million time-domain events per night, detected and transmitted to event distribution networks within 60 seconds of observation.
- A catalog of orbits for ~6 million bodies in the Solar System.

Prompt data products

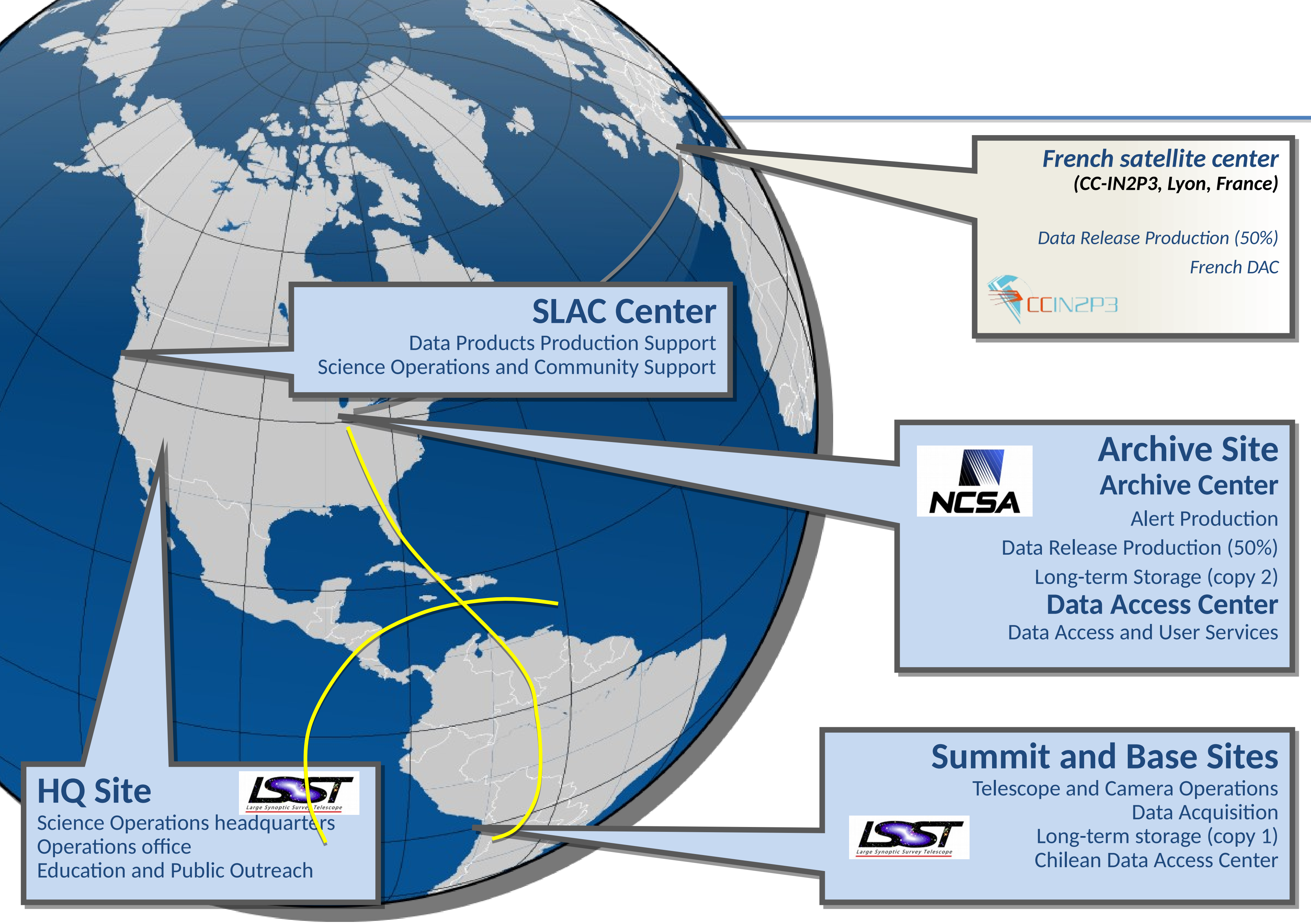
- A catalog of ~37 billion objects (20B galaxies, 17B stars), ~7 trillion observations (“sources”), and ~30 trillion measurements (“forced sources”), produced annually, accessible through online databases.
- Deep co-added images.

Data Release products

- Services and computing resources at the Data Access Centers to enable user-specified custom processing and analysis.
- Software and APIs enabling development of analysis codes.

User Generated data products

Slide borrowed and adapted from Mario Jurić


French satellite center
(CC-IN2P3, Lyon, France)
Data Release Production (50%)
French DAC
CCIN2P3
SLAC Center
Data Products Production Support
Science Operations and Community Support
Archive Site
NCSA
Archive Center
Alert Production
Data Release Production (50%)
Long-term Storage (copy 2)
Data Access Center
Data Access and User Services
HQ Site
LSST
Large Synoptic Survey Telescope
Science Operations headquarters
Operations office
Education and Public Outreach
Summit and Base Sites
Telescope and Camera Operations
Data Acquisition
Long-term storage (copy 1)
Chilean Data Access Center
LSST
Large Synoptic Survey Telescope

Data Release Processing

France has signed up an MOA with LSST where

- France will process 50% of the Level 2 Data Release Processing (DRP)
  - The other 50% is processed at NCSA
- France will hold a complete copy of the LSST data

NCSA is responsible to coordinate the whole DRP

In exchange of this contribution France gets 45 data rights

Data Access and Science analysis is not covered by this agreement

Data right ≠ Data access

The IN2P3 Computing Center
CC-IN2P3

2 computer rooms

CPU:
- 31 000 cores (330 000 HEPSpec06)

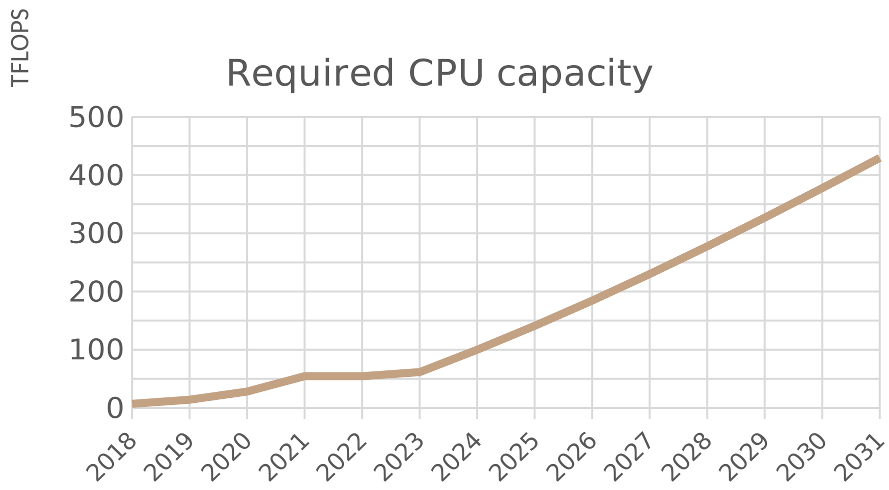
Disk storage:
- DAS : 22 PB
- Shared Filesystem GPFS: 2.2 PB

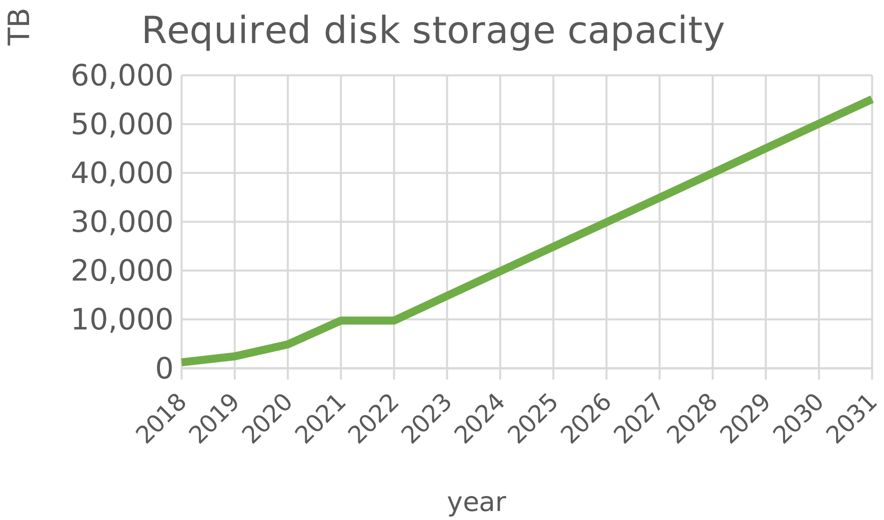
Mass Storage:
- 4 tape robots (340 PB nominal capacity)
- 50 PB in use

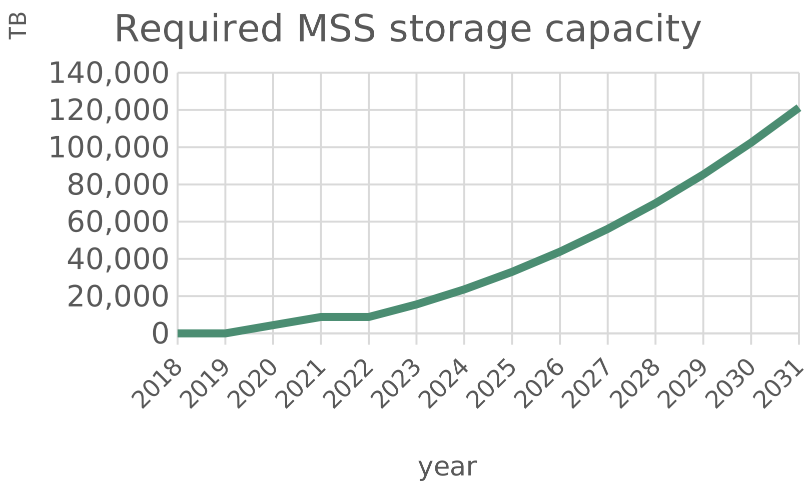
Main computing center in France for HEP, Nuclear Physics, Astroparticles and Cosmology
- ~65 highly skilled computing engineers
- Operating 24/24 – 365/365

- Tier-1 for the 4 LHC experiments within the Worldwide LHC Computing Grid
- Supporting ~70 experiments / projects

Capacity planning for LSST DRP@CCIN2P3







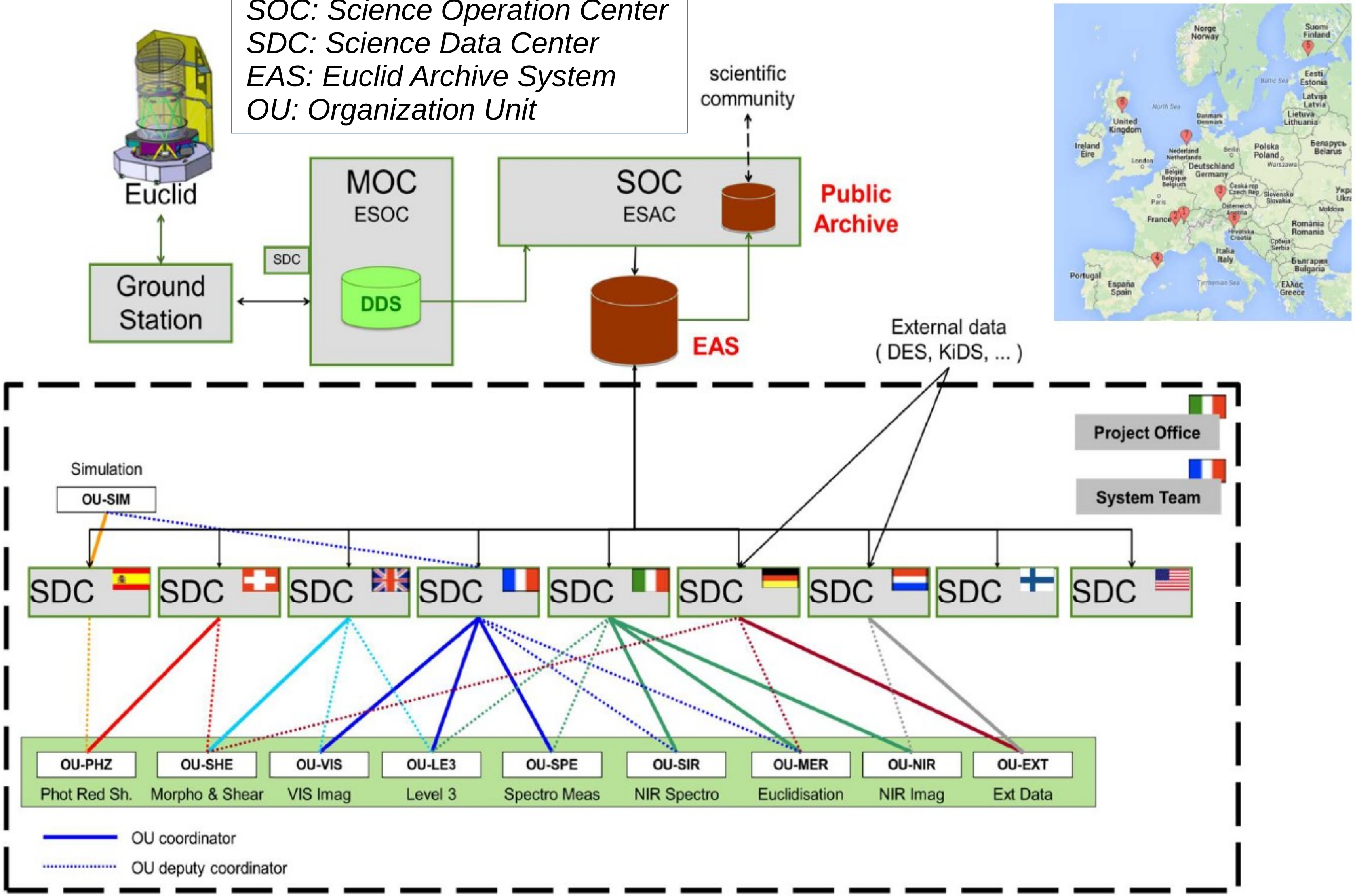
Up to 1.4 MW of electrical power in 2028 (1.2 M€)

From Fabio Hernandez (LSST project leader at CC-IN2P3)

Euclid Science Groud Segment (SGS)

Euclid Consortium

MOC Mission Operation center
SOC: Science Operation Center
SDC: Science Data Center
EAS: Euclid Archive System
OU: Organization Unit



Science Vs Engineering

- The original LSST model is mostly centralized
  - This may change a little bit though...
- LSST the Science Collaborations are separated from the LSST project
  - This has some consequences
    - LSST software development is managed as an engineering project
    - Functionalities and performance goal has been defined largely independently from the science requirements
    - Science collaborations (DESC) have little knowledge of what is going on on the LSST DM side
      - Risks to re-invent the wheel

Crucial to build a bridge between both sides

⇒ Science Driven Software Validation

The LSST DM Stack

The choice of the Data Management team has been to re-use existing algorithms whenever possible but to rewrite everything from scratch

- Considerable experience from previous projects especially SDSS and also from current ones : HSC, DES, …

Develop a modular, efficient and versatile image analysis framework

- ~50 M$ funding for construction and commissioning of the LSST stack and associated middleware
- All the code is open source : https://github.com/lsst

Code is in Python and C++

- Standard users are dealing with Python modules

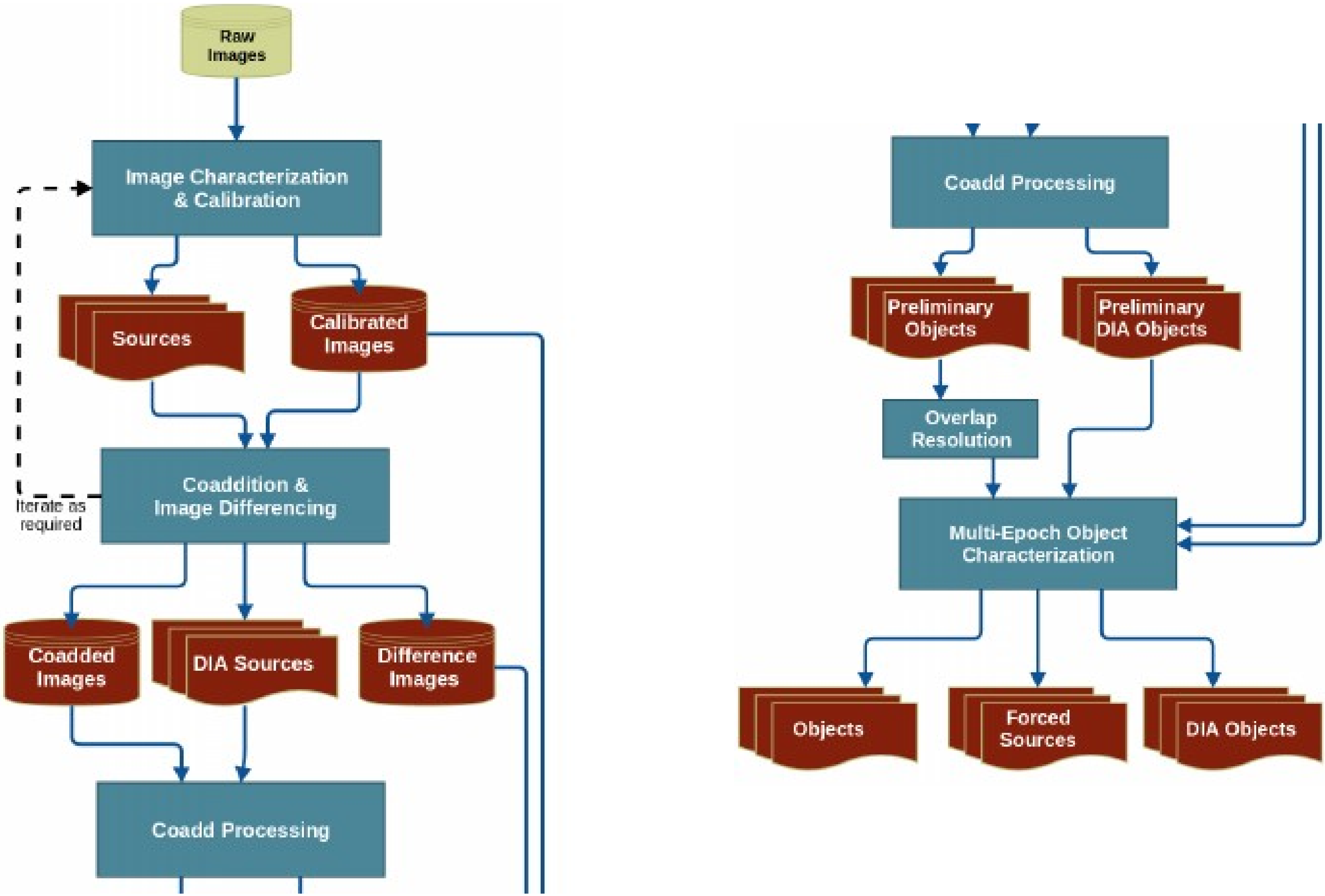
Designed to support any CCD-based instrument : SDSS – HSC – CFHT – DES…

- DM stack is the official software package for HSC image processing

⇒ ***The LSST DM stack is a complex software system. Building up experience with it is a very important goal for LSST-France***

HSC image processed through the DM stack at CC-IN2P3

Image processing step by step



Where are the bottlenecks ?

International Network: Is not a problem anymore as long as we anticipate enough (years) – 100 Gb/s links are now ~standard

CPU power: Is a terrible waste nowadays as we use only a few % of the theoretical Flops

- Image processing is essentially an embarrassingly parallel problem
- scaling can be achieved by multiplying the number of cores (*see next point*)
- Supercomputer are not well adapted to image processing with current algorithms

I/O : combination of storage and local network

- This is the most critical point
- May reduce significantly the CPU efficiency (CPU / Elapse)
- Astronomy image processing can be very I/O intensive (basically when is reading or writing every single pixels)
- Tests have demonstrated that using SSD can help a lot
  - Costly ⇒ need to use at the right place

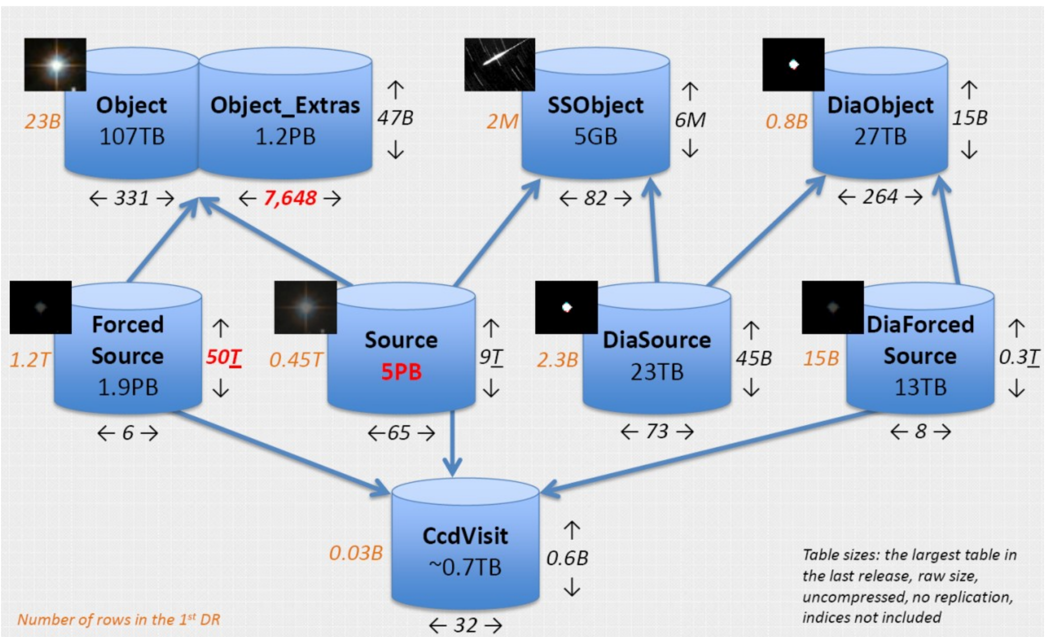
Memory :

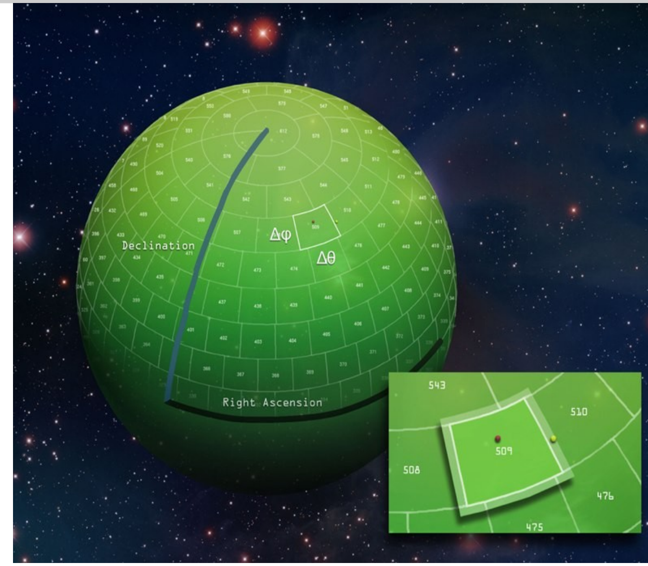
- Ok for most of the processing steps
- Critical for multi-visit full focal plane fit
  - Sparse matrices algorithms
  - May require a few very large memory machines ($$$)

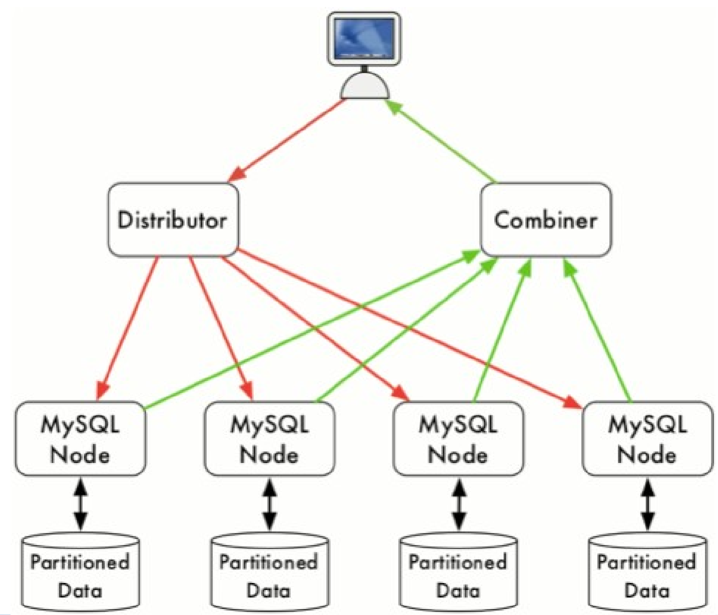
The database : a key component

The challenge is to design an SQL database system able to store trillions of objects while keeping a the access time at a reasonable value

Qserv : developed at SLAC – Design optimized for astronomical queries







Massively parallel – distributed – fault tolerant **relational database**

Final relelease : ~15 PB

Qserv@CC-IN2P3

CC-IN2P3 has a partnership with Dell

Setup Qserv test bench

- 50 servers (2 test benches x 25 servers)
- 400 cores
- 0.5 PB disk storage

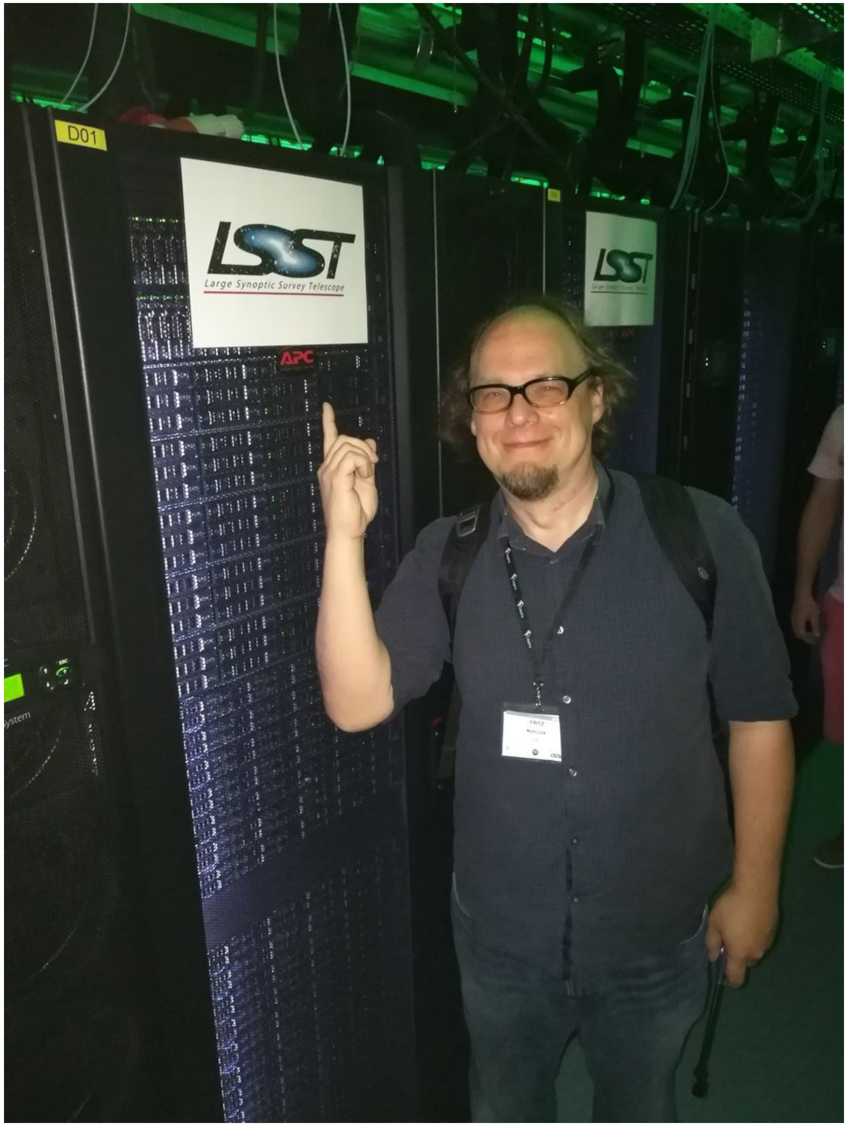
Heavily used by Qserv developers for integration and performance tests

In parallel LSST-France is running another Qserv instance to test the Database from the ***science perspective***

- Ingest galaxy cluster data and repeat analysis
- Plan to ingest the DESC DC2 catalog

Alternatives to Qserv are also considered by the LSST DM

⇒ Final decision soon



DESC 2nd data challenge (DC2)

Full simulation starting from a 5000 deg² extragalactic catalog from a large scale cosmological simulation + Galaxies + Stars + Strong Lensing + Transients…

Main survey:

- Area: 300 deg²
- Survey depth: 10 years
- Using the latest optimized cadence model + dithering scheme
- Visits: (ugrizy) = (56, 80, 184, 184, 160,160) x 30 fields ~27 000 visits

Ultra Deep Drilling Field:

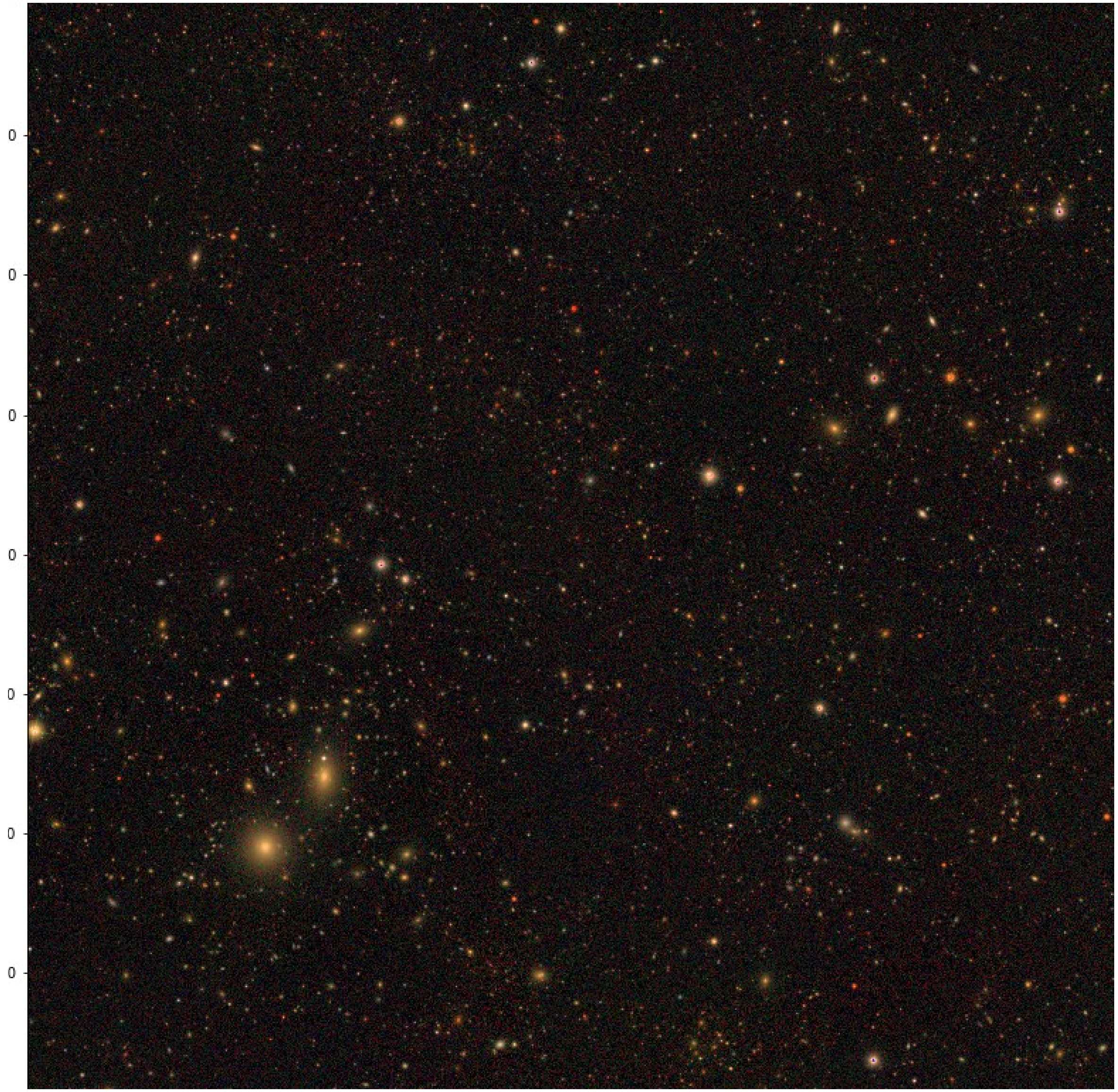
- 1.25 deg²
- 10 years
- 20 000 visits

- 2 independent simulators
  - Phosim – raytracing
  - Imsim – derived form GalSim
- Includes some sensor effects

9. 10^6 raw data files
Final catalog probably ~200 TB

On top of the science aspects we consider DESC DC2 as essential to get prepared for the LSST DRP

DESC DC2 coadded image from one sky patch (4k x 4k)



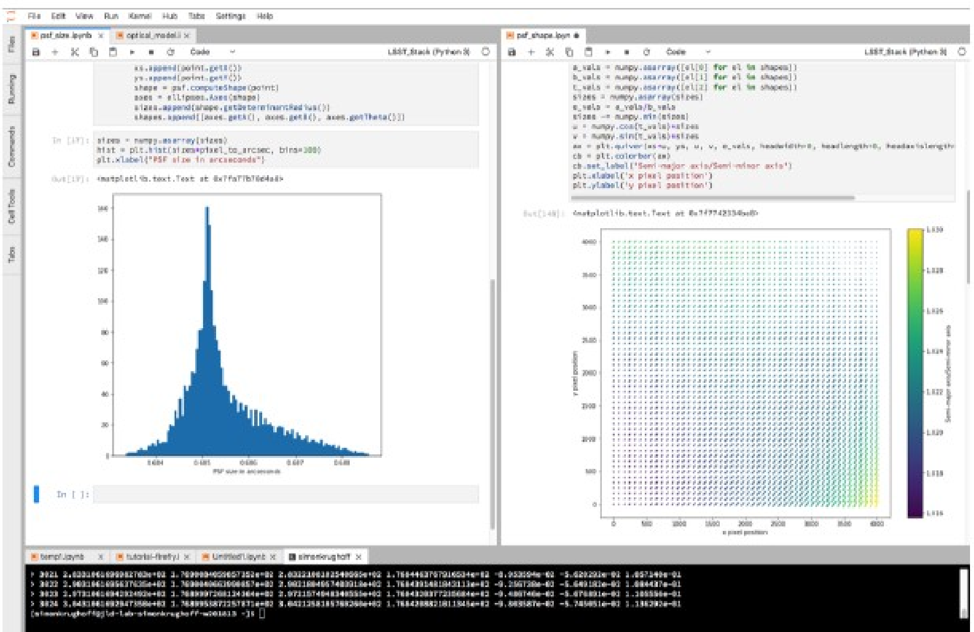
Data Access Centers (DACs)

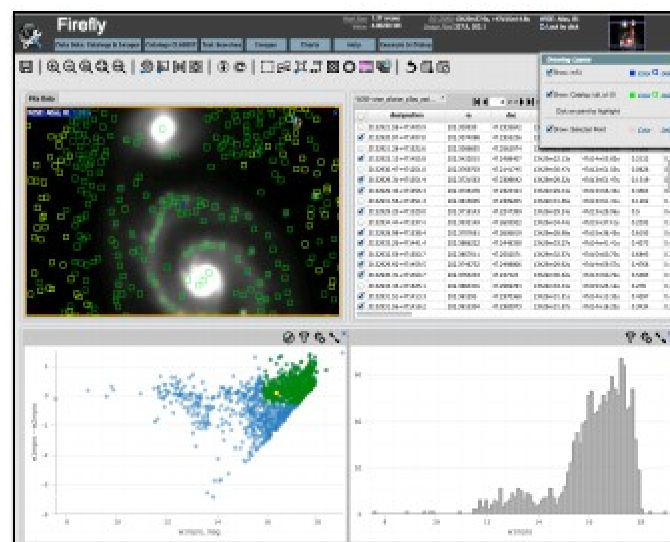
In LSST: officially 2 DACs in Chile and at NCSA

- Sized to provide data access to ~7500 potential users
- Currently evaluating the possibility to have a few (3-4) International DAC
  - The European LSST community is trying to get organized

In France there will be an LSST DAC

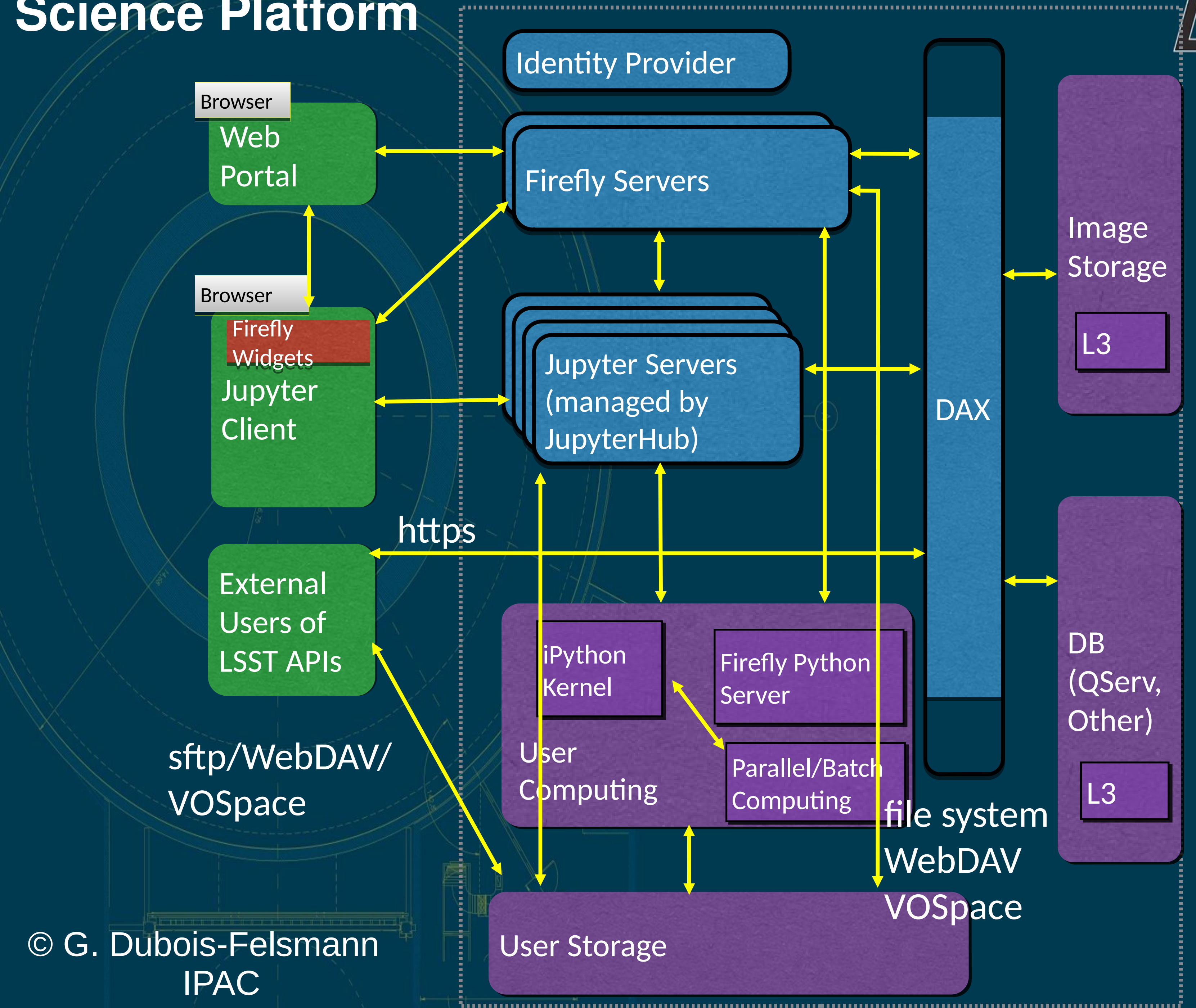
- At minimum to serve the French LSST community
- May be extended to the European / Worldwide partners





The Firefly Web Science User Interface (Wu et al, 2016; ADASS)

Science Platform



Science User Interface

- Every projects needs to provide a Science Interface
- But this is clearly a place where we could put the efforts in common
- A lot of experience at CDS Strasbourg
- Big scientific interest to extend the interfaces in order to access complementary data
  - Transient follow-up
  - Spectroscopic data
  - Multi-wavelength
  - Multi-messenger

Challenge : scale up the existing tools to match the large astronomical surveys

There are a couple of initiatives:

- ESCAPE: European project in the European Open Science Cloud framework
- LSST-Europe tries to federate in order to define a common approach
- ...